Coarse woody debris and soil organic carbon in managed and unmanaged forests

Inken Krüger*, Christoph Schulz**, Werner Borken*

* University of Bayreuth, Department of Soil Ecology
** Bavarian State Institute of Forestry, Freising
Forest management

- Different extents of biomass removal and soil disturbance
- Stronger influence on the forest floor than on mineral soil
- Few practices clearly good or bad with respect to C sequestration (Jandl et al. 2007)
Coarse woody debris as a carbon sink

- CWD stock
  - Up to 550 m³ ha⁻¹ in protected beech forests (Christensen et al. 2005)

- Organic layer
  - CWD influences the $^{14}$C signature of the organic layer (Trumbore and Harden, 1997)

- Mineral soil
  - No increase in carbon stocks below beech logs (Kahl, 2008)
Objectives

- How much carbon is stored in CWD in unmanaged and managed forests?
- Does CWD affect the C stock and turnover of the soil?
Study sites

Rohrberg/Spessart
Beech-oak forest
Protected since 1928

Ludwigshain
Oak-beech forest
Protected since 1913

Grübel/Bavarian Forest
Spruce forest
Protected since 1978
Analyses

Managed and unmanaged forests

- Total CWD
- Organic layer (n=30)
- Mineral Soil (n=30)
Analyses

Managed and unmanaged forests

Total CWD

Stand age
Time of death
Stocks

Organic layer (n=30)

Mineral Soil (n=30)
Analyses

Managed and unmanaged forests

Total CWD

Organic layer (n=30)

Mineral Soil (n=30)

Stand age

Time of death

Stocks

FWD

Leaf litter

Oi

Oe

Oa
Analyses

Managed and unmanaged forests

Total CWD

Stand age
Time of death
Stocks

Organic layer (n=30)

FWD
Leaf litter

Mineral Soil (n=30)

0-10 cm
10-20 cm
20-50 cm
50-100 cm

FPOM <1.6 g cm⁻³
OPOM 1.6 - 2 g cm⁻³
MAOM >2 g cm⁻³
Analyses

Managed and unmanaged forests

Total CWD

Organic layer (n=30)

Mineral Soil (n=30)

Time of death

Stand age

Stocks

Oi

Oe

Oa

FWD

Leaf litter

0-10 cm

10-20 cm

20-50 cm

50-100 cm

FPOM <1.6 g cm^{-3}

OPOM 1.6 - 2 g cm^{-3}

MAOM >2 g cm^{-3}

^{14}C measurements
C stocks of CWD

- Spruce 1978
  - Managed (M)
  - Unmanaged (UM)
- Beech – Oak 1928
  - Managed (M)
  - Unmanaged (UM)
- Oak – Beech 1913
  - Managed (M)
  - Unmanaged (UM)
C stocks of CWD and organic layer

Spruce 1978
Beech – Oak 1928
Oak – Beech 1913

M       managed
UM    unmanaged

FWD    CWD
O_i
O_e
O_a
$^{14}$C measurements

- Calculation of turnover time (TT)
- Indication of C origin
\( ^{14}\text{C} \) measurements

- Calculation of turnover time (TT)
- Indication of C origin

![Graph showing \( ^{14}\text{C} \) measurements over time](image-url)
$^{14}$C measurements

- Calculation of turnover time (TT)
- Indication of C origin

Diagram showing $\Delta^{14}$C measurements over time for different turnover times (TT). The diagram includes lines for atmosphere, TT=1a, and TT=28a.
$\Delta^{14}C$ Signature of organic layer

Spruce

Beech – Oak

Oak - Beech

CWD (calculated)

<table>
<thead>
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<th></th>
<th>UM</th>
<th>45%_0</th>
<th>6%_0</th>
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<td></td>
<td>15%_0</td>
<td>M</td>
<td>45%_0</td>
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<tr>
<td></td>
<td>135%_0</td>
<td></td>
<td>101%_0</td>
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</table>
**Model of turnover time**

Turnover time unmanaged = Turnover time managed

**Steady state model:**
Carbon stock = const.

Input = Output = Carbon stock / Turnover time

**Non-steady state model:**
Carbon stock ≠ const.

Stand age = time of $O_e$ upbuild
Fate of CWD

- Total C loss
- C input in $O_e$

Managed (M) vs Unmanaged (UM)

Spruce 1978
Beech – Oak 1928
Oak – Beech 1913
Carbon stocks of mineral soil

Spruce
1978

Beech – Oak
1928

Oak – Beech
1913

Managed (M)
Unmanaged (UM)

0-10 cm
10-20 cm
20-50 cm
50-100 cm
$\Delta^{14}C$ Signature of mineral soil

**Spruce**

**Beech – Oak**

**Oak - Beech**

<table>
<thead>
<tr>
<th>0-10 cm</th>
<th>10-20 cm</th>
<th>20-50 cm</th>
<th>50-100 cm</th>
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<tbody>
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$\Delta^{14}C$ / ‰
Δ^{14}C Signature of FPOM

Spruce

Beech – Oak

Oak - Beech

Δ^{14}C / %o

unmanaged

managed
Conclusions

- Forest management had no impact on soil C stocks in our study sites

- Increase of CWD by 5 - 27 t C ha\(^{-1}\) since protection (0.1 - 0.3 t C ha\(^{-1}\) a\(^{-1}\))

- No or minor influence of CWD on \(^{14}\)C signature of mineral soil fractions
Thank you

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